Lateral structural variation and seismic activity in the central part of the NE Japan Arc from the 2019 onshore seismic profiling -II

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Detailed structural variation in the crust and upper mantle under Central NE Japan arc was obtained from a series of integrated analyses from 2020 for onshore seismic refraction/wide-angle reflection data (Iwasaki et al., 2024, 2023a,b). These data were acquired in 2019 as the onshore part of the extensive onshore-offshore seismic expedition from the Yamato bank in the Sea of Japan to the Japan trench (Sato et al., 2021a,b). Our model for the whole crust and uppermost mantle (Fig. 1) has following features.
(1) Upper crust : The uppermost crust, which corresponds to sedimentary and volcaniclastic rocks, consists of undulated layers with Vp=1.6~5.5 km/s. Their geometry is well correlated with fault and caldera systems developed under successive tectonic processes in the NE Japan arc. The upper crystalline crust is composed of two parts. The upper part, 1.5-2.5 km thick, has a velocity ranging from 5.65~5.8 to 5.8-5.9 km/s. The velocity at its top shows a higher value (5.8 km/s) in the western part (the backarc basin basalt area) but decreases to 5.65-5.7 in the central part of the profile. Beneath the felsic caldera complex area (Ou backbone range), there exist local reflectors at a depth of 4-6 km with a velocity contrast of ~0.1 km/s. The velocity in the lower part is estimated as 6.0-6.2 km/s. The easternmost part (Kitakami Mts.) is characterized by an upper crustal block with a high velocity (Vp~5.0-5.9-6.3 km/s) descending westward beneath the Kitakami river valley. Such a feature represents the major geological structures including the Sue fault, Asahiyama flexure and Kashimadai fault.
(2) Middle/lower crust : The middle crust in our model is expressed as a 6-7 km thick layer with a velocity of 6.3-6.5 km/s. The velocity contrast between the upper and middle crust is 0.1-0.15 km/s with lateral fluctuation. The lower crust, composed of three layers with velocities ranging from 6.6 to 7.1 km/s, is generally reflective. At the bottom of the lowermost crust, there exists a 2-km thick high velocity gradient zone of 1.5- 2 s^{-1}, probably representing transition from the uppermost mantle to the lower crust material.
(3) Moho and uppermost mantle : The Moho is situated at 30.5-32 km depth. The Pn velocity is about 7.7 km/s. Due to the transition zone mentioned above, the velocity contrast at the Moho becomes only 0.2~0.3 km/s. The uppermost part of the mantle contains two velocity discontinuities at depths of 38 and 46 km with a contrast of 0.1~0.2 km/s.

The seismic activity beneath our profile line is well correlated to the lateral structural variation mentioned above.
(1) The Kitakami river valley to the Kitakami Mts. : Most of crustal events are occurring at depths of 2~15 km. The recent significant activity in this region is the 2003 Northern Miyagi earthquake (Mj 6.4) occurring around the Sue fault. Following aftershocks are distributed in the western half of our higher velocity block (Kato, N et al., 2004). Along the western boundary of this block, we also see some seismic activity extending to 15-km depth. In contrast, the seismicity beneath the Kitakami river valley is very low, indicating that the structure between these two blocks forms a significant mechanical boundary as well as the geological boundary.
(2) The felsic caldera complex area : Earthquakes in this area are concentrated at shallower depths (< 7-8 km), probably due to a shallower brittle-ductile transition zone associated with the volcanic activity.

(3) Backarc basin basalt area : This area is characterized by rather high and deep seismicity extending to the lower crust. This suggests westward descending brittle-ductile transition zone, but the corresponding structural feature has not been found in our research as yet.

(4) Low frequency earthquakes : Low frequency events are occurring at depths of 17-40 km just within the reflective zones in the lower crust and upper mantle, suggesting upward fluid migration.

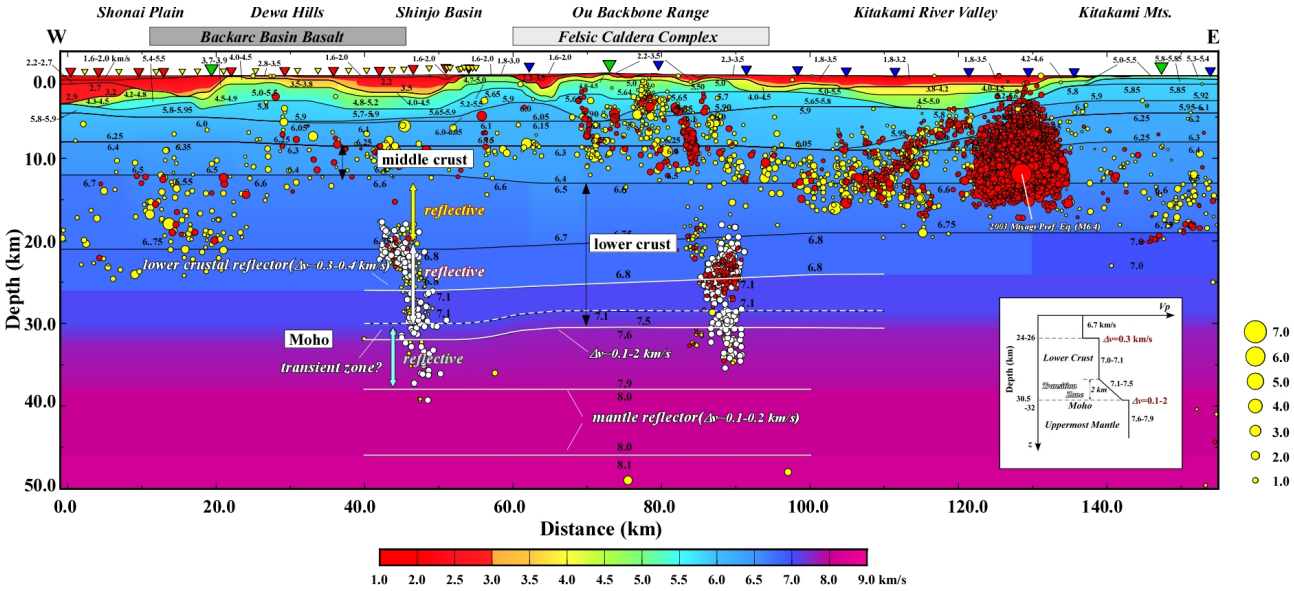

Fig. 1. Velocity structure model and seismic activity. Yellow circles: hypocenters from 2014-2023. Red circles: hypocenters from 2003 to 2004 incl. the 2003 Northern Miyagi earthquake and its aftershocks. White circles: low frequency earthquakes from 2010 to 2019. All of the hypocenters are provided from JMA.